Interferometry in space: lead-in talk

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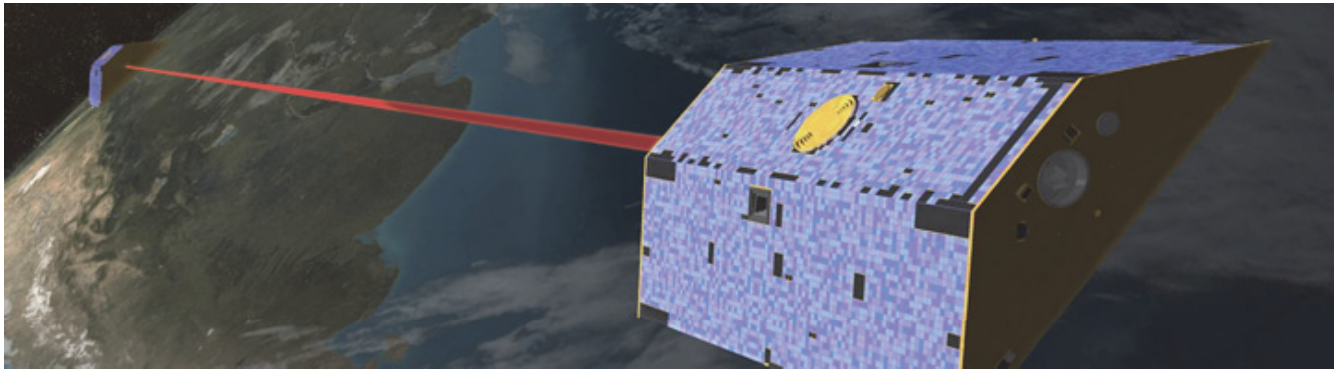
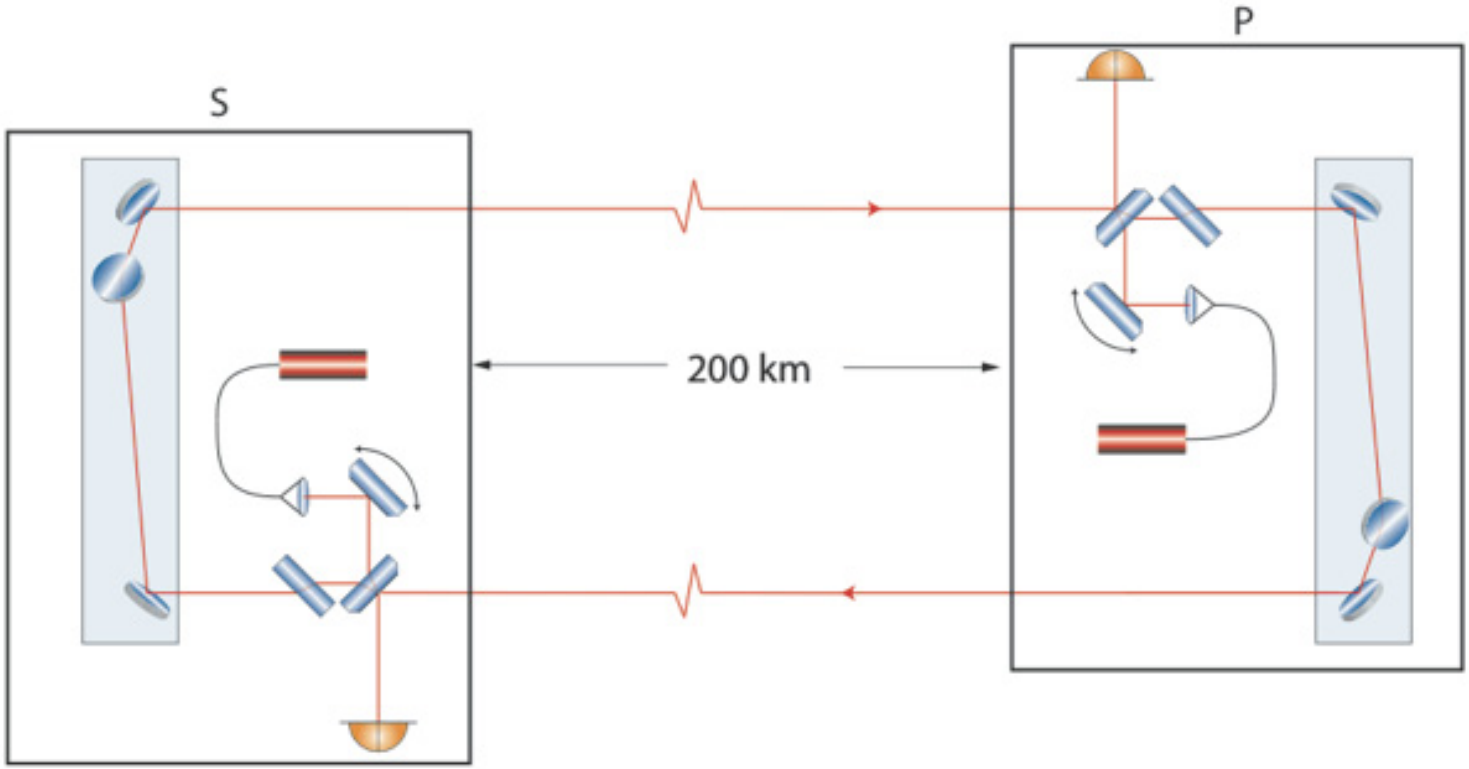
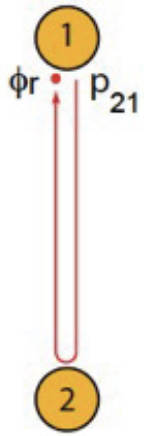
GRACE: the first interferometer in space



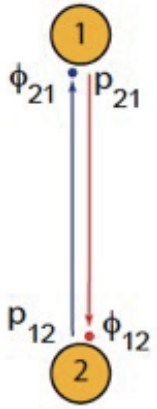


GRACE Measurement as Time-Delay Interferometry



$$\begin{aligned} \phi_r(t) &= [D_{21}D_{12} - 1]\, p_{21}(t) \\ D_{ij}\, a(t) &= a(t - L_{ij}/c) \end{aligned}$$

- Conventional mirror-based self-delay interferometer
- Measurement is (prompt)−(delayed)



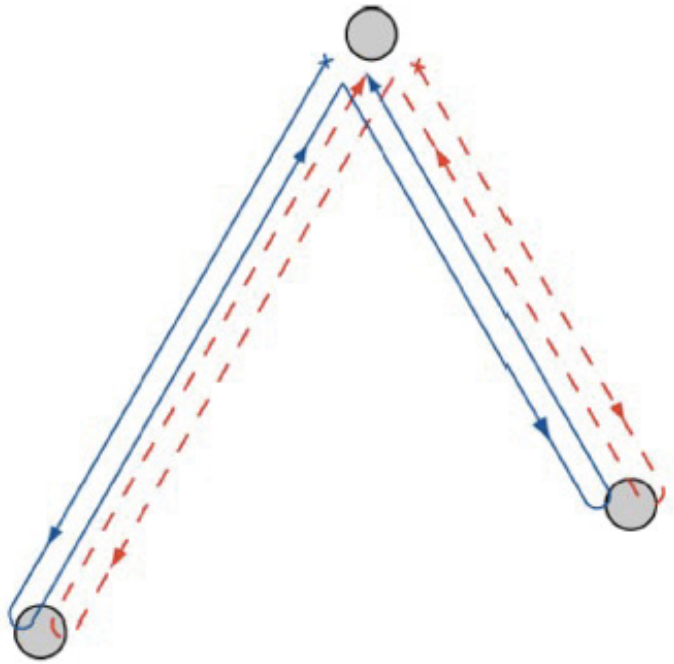
$$\begin{aligned} \phi_{21}(t) &= D_{21}p_{12} - p_{21}(t) \\ \phi_{12}(t) &= D_{12}p_{21}(t) - p_{12}(t) \\ \phi_r(t) &= \phi_{21}(t) + D_{21}\phi_{12}(t) \end{aligned}$$

- Synthesized from symmetric one-way measurements
- Two lasers, two measurements
- Measurements combined using knowledge of delays

Michelson interferometry by TDI

Simplest TDI combination canceling frequency noise: Michelson interferometer

- Separate lasers and phasemeters at vertex
- Arms are unequal, optical subtraction would be sensitive to frequency noise
- Symmetrized path synthesized by delaying and adding separate arm measurements
- Rejection of frequency noise limited only by knowledge of delays
- Same sensitivity to differential strain as conventional Michelson



First-order Shaddock Diagram

Prime candidate for quantum techniques in space: DECIGO gravitational-wave detector

No options for squeezing on LISA -- Yanbei's talk yesterday -- but DECIGO (or BBO or Astrod,...) is another story

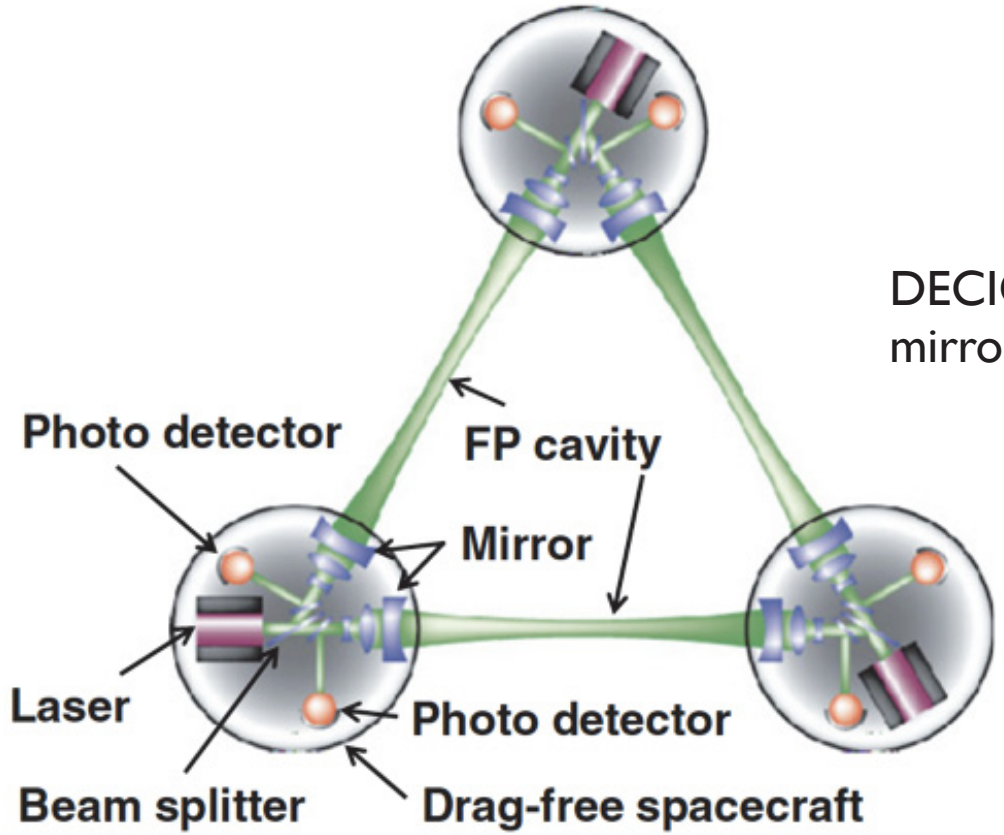
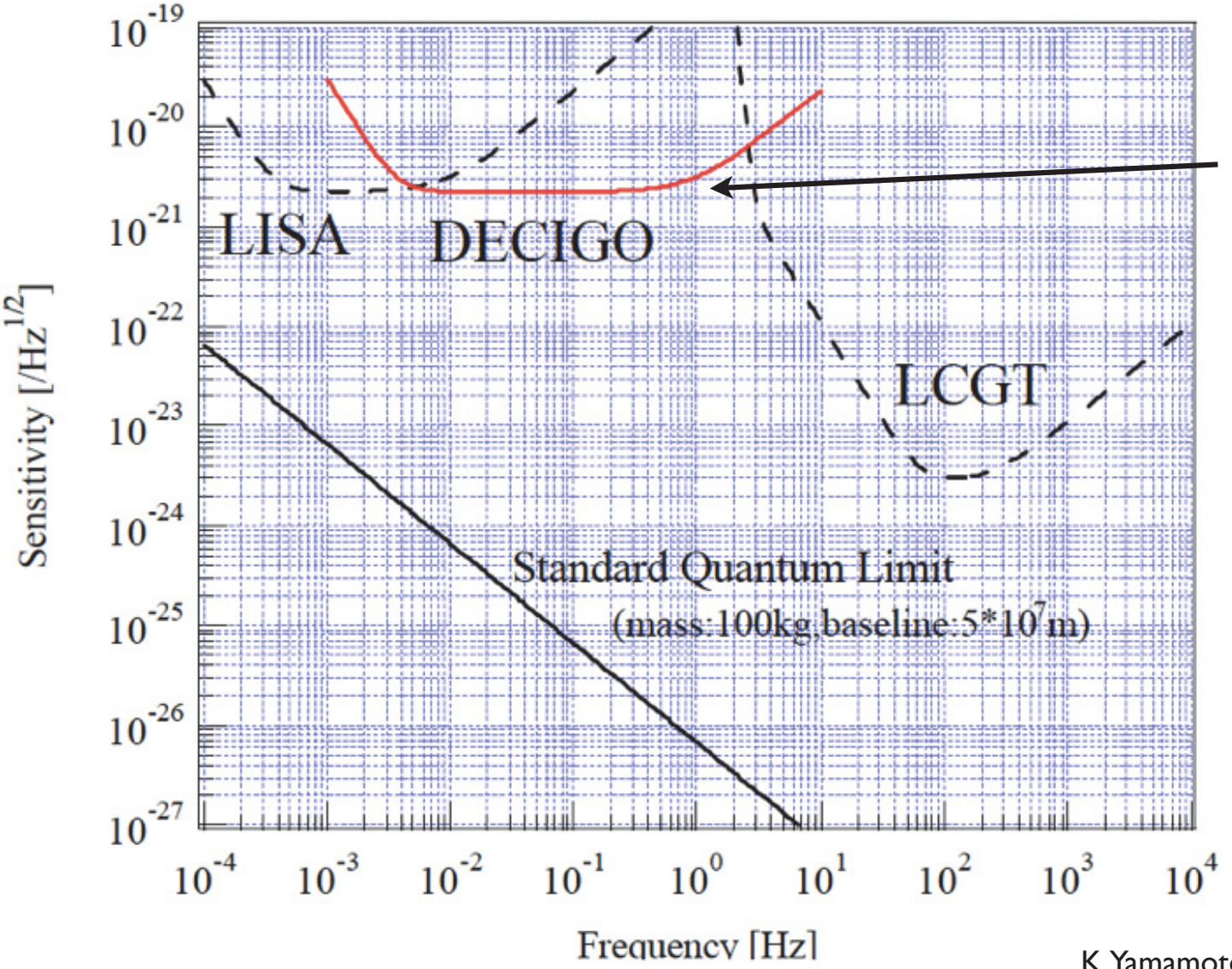


Figure 1. Pre-conceptual design of DECIGO.

DECIGO has short arms and large mirrors for arm cavities

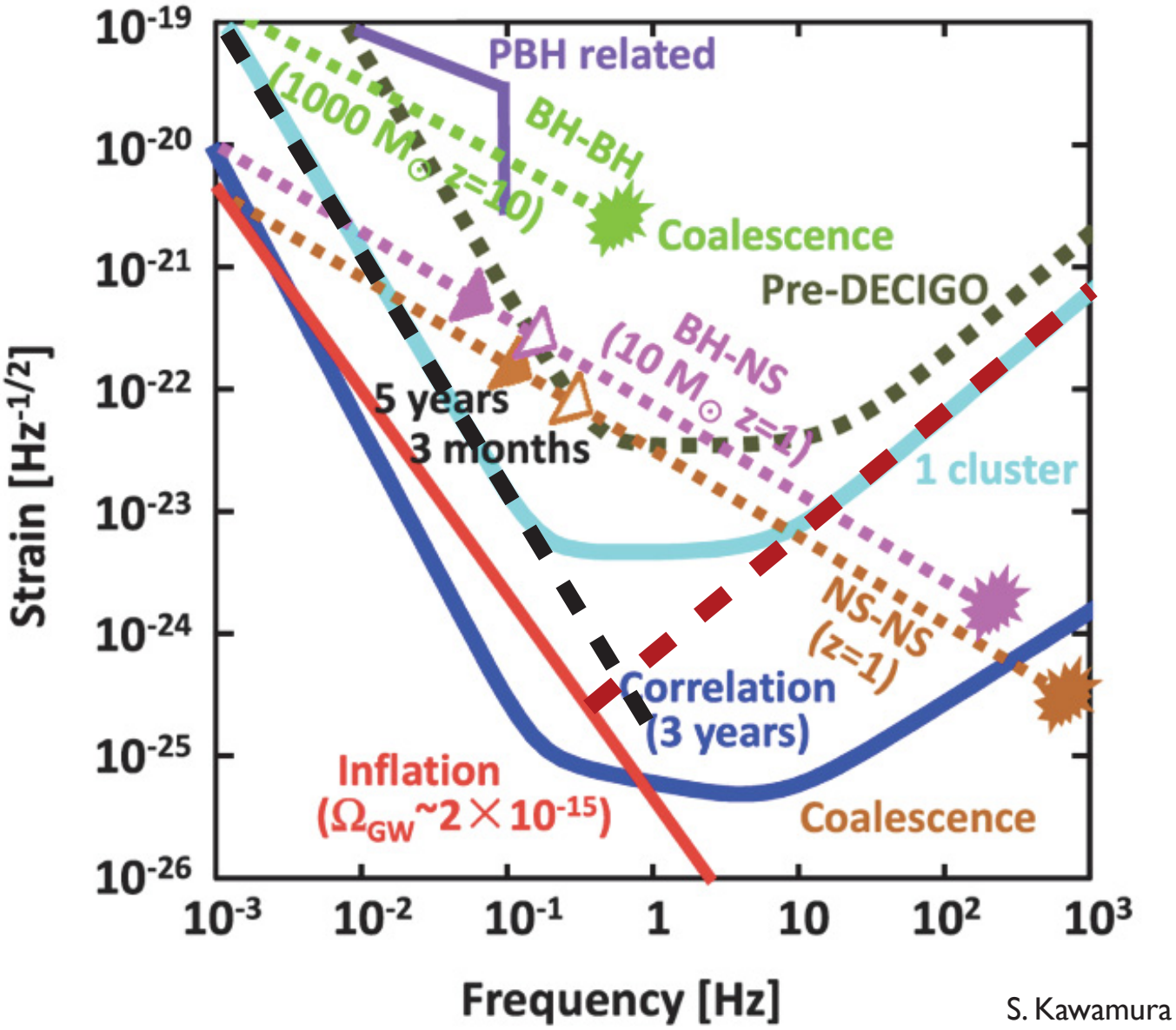
2003 concept: Big gap to quantum limit



Arm length
= 50,000 km

K. Yamamoto

Current concept: Limited by radiation pressure below 0.15 Hz, shot noise above 0.15 Hz



L = 1000 km
P = 10 W
m = 100 kg
Finesse = 10

S. Kawamura

Practical Limits

• Phase squeezing: Finesse = 10 implies large optical loss, limiting improvement at high frequency from squeezing. But, should be easy to increase finesse.

• Amplitude squeezing: 1000 times better acceleration noise than LISA: very difficult!